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THE TRIP TO ATLANTA

By C. C. WILLIAMS

President of the Society

The trip to Atlanta next June should not be squeezed down to a minimum of time, especially for those who drive. By planning, clustering about the main event and the necessary travel, those incidental sources of enjoyment and value that may be had for the taking of forethought, the convention can be made the nucleus of a rich experience that will long be cherished after the inconvenience of taking the time away from regular duties has been forgotten.

Four types of side interests may be seen: technical, scenic, historic, and modern progress.

The long reaches of paved highways and the truly remarkable bridges over major streams are usually taken for granted, yet their creation in about two decades is nothing short of marvelous, and some of the latest developments may be seen enroute. Wilson dam at Muscle Shoals, Norris dam, Dix River dam, the rock asphalt mines of Kentucky, the canalization of the Ohio and its tributaries, marble quarries, iron and steel plants, glass factories, textile mills, numerous steam and hydro-power plants are within convenient reach from the highways. Many colleges of engineering, each with its peculiar traditions and problems will well repay the side trips to them. The whole TVA project, exemplifying certain political tendencies and destined to be the storm center of widespread controversy in the future, will doubtless be a primary objective for all who journey that way this summer.

Scenic attractions include natural wonders such as the Mammoth Cave, the Luray, Crystal and Weyer caverns, Warm Springs, Blowing Cave, Crabtree Falls with a descent of 500 feet, in addition to those charming quiet spots of nature that rest and delight the soul, such as the Blue Grass Country, Cumberland Gap, and the streams and peaks of the Great Smoky Mountains. Stone Mountain and the famous memorial of valor lies 17 miles east of Atlanta.

For those with a taste for history, the trip will be a treat. Going or coming, re-visit Mount Vernon, the "shrine of each patriot's devotion," and receive from its quiet beauty, its simple dignity, and the heartfeld homage at the tomb of the General, a fresh inspiration and a quickened faith in the country's destiny;

go to Williamsburg, restored to its colonial condition, and form a conception of how the Revolutionary fathers lived; see Monticello, coupled with certain political idealisms, and Jamestown where much American enterprise had its beginnings; drive the ten miles over to Yorktown to see the ramparts where a great loyalty was vindicated; see Houdon's Washington in the state house at Richmond; and, after St. John's church (the scene of Patrick Henry's impassioned appeal) and other sights of that historic city, return again to the state house to see the statue of that strong graceful figure. The Peninsula, Chickamauga, Kennesaw Mountain, Hampton Roads, and Appomattox lie along the road. In fact, the trails all the way from Memphis and from Washington to Atlanta are well monumented and parked at the sites of major or minor engagements in that great struggle, the culmination of political passions in the nation.

Perhaps of transcendent interest will be those evidences of the recent progressiveness and the established fine culture in the southern states, which characterize the cities and the educational institutions. The University of Georgia at Athens is the oldest state university, and recent reorganization of higher education in that state will be of interest to visiting members, especially those of the administrative group. The convention will fail of its purpose in part if, after we have returned to our homes, we do not feel better acquainted and more appreciative of the splendid work that the members and member institutions of the South are doing and the masterly manner in which they are solving their problems. The meeting at Atlanta, the "Pinnacle City" of the "Empire State of the South," should be more than just another convention; it should be an event.

ADDITIONAL INFORMATION RE ENROLLMENT IN ENGINEERING SCHOOLS

Published in November, 1934, JOURNAL OF ENGINEERING EDUCATION, p. 260. The attendance and the percentages are given as received from the institutions.

F. L. BISHOP, *Secretary*

February 26, 1935

Institution	Freshman		Sophomore		Junior		Senior		Graduate Students		Special Students		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Brown Univ.	35	—	26	—	26	—	24	—	5	—	—	—	116	—
Clemson Coll.	170	+52	86	− 8	76	+ 9	66	−28	—	—	—	—	398	+ 7
*Colo., Univ. of	180	+42	130	+ 4	118	− 4	114	+ 8	25	+25	—	—	567	+15
					Pre-Juniors									
					108	+27								
Drexel Inst.	264	+14.7	132	− 5.7	64	−38.4	92	+12.1	—	—	3	—	663	+ 2.9
Iowa St. Coll.	361	+33	302	− 1	174	−17	232	−12	36	−18	3	−57	1108	+ 0.5
Minn., Univ. of	439	+39	352	+14	393	+10	393	− 7	163	—	—	—	1740	+ 4
†Purdue Univ.	721	+27	539	+10	462	−10	444	− 2	61	—	5	—	2176	+ 7
Texas Tech. Coll.	226	+22.2	110	+26.4	55	+28	44	−18.5	5	+66.6	—	—	440	+18.3

* Corrected 12–30–34.

† Corrected 12–11–34. In addition to the above there are 18 Fr., 2 So., 8 Jr., 13 Sr., 2 Specials enrolled in industrial education.

GOOD TEACHING

By J. S. DODDS

Professor of Civil Engineering, Iowa State College

Character is the first essential to good teaching. High character is as necessary as knowledge of subject. High character in a teacher is evident in his desire to develop the best in his students and in his coöperative relation to his fellow faculty members.

Teaching technique without character is like the movements of a heartless robot. It goes through the motions but there is no heart pulsing with human warmth. The very word teach means leader and a leader without high character is almost inconceivable.

Many a skilled person, many a brilliant man fails as a teacher because he has a notion that he is separate from his subject and what he does personally is not important to his students. The teacher without high character fails in his contacts with his students.

A teacher's obligation to his fellow faculty members is no less a matter of character. Many a teacher loses out in his influence upon his students because of a lack of loyalty to his superior or his associates. In no remark or inference will a good teacher slight another staff member in the hearing of students. If a situation arises which seems to give an opportunity to put another teacher in a hole it is always possible to protect the other by a careful word or by an easy assumption of responsibility which is respected by the student. Never discuss another faculty man with students.

Perhaps this is enough to say about my first point. The need for high character in the teacher is obvious. The president of the college loses no opportunity to emphasize the ambition he has to turn out students of good character.

Next to good personal character in this analysis comes class room decorum or the teacher's actual conduct of the class. From the moment the professor enters the classroom on the stroke of the clock until the fifty minutes are up, there must be no doubt as to who is in command of the situation. Like the old saying, "The marines have landed and have the situation well in hand." A teacher with less than 20 students can tell with one look if all are present without calling the roll.

A teacher who sums up the last lesson by a well-put question or two, then opens up the day's lessons with a few minutes of questions, either oral or written, and then spends the major part of the

hour on collateral matter not in the text assignment, keeping everyone on his toes because he is on his toes, then closes with a quick review of the main points for the day and a one-minute picture of what is expected from the next lesson, will have the respect of himself and his class. When talking, his manner must be convincing and absolutely clear and intelligent.

The teacher's conduct of the class is the part he plays to insure that the student does his work and gets the greatest possible benefit from the class.

The third point in good teaching is the knowledge of the subject. That part of the work must be up-to-date and preferably first hand. This first hand point of view is so important that a recent report on competition by teachers and salaried engineers with professional practitioners conducted by the Founder Societies encourages participation in consulting work not of routine character by engineering college professors.

Current knowledge of the subject is gained by working during vacations, visits to work in progress, inspection trips to factories, serving on research committees, participation in professional programs, reading all possible current literature, visits on every possible occasion with other engineers who are engaged in the branch, and actual consulting work when time permits.

Back of the current knowledge of the subject is the fundamental education which every good teacher must have so that he can liven his discourse with clear, intelligent illustration. Habitual grammatical error is inexcusable in a classroom lecture.

The fourth element of better teaching is a keen, broad understanding of the relation of the subject to the whole field of engineering and, more particularly, to the economic life of the community in which we live. No engineering teaching is at its best if it sets the subject apart from other activities and deals with it as if it had no relation to everyday affairs.

If the teacher is of good character, on his toes in the class room, knows his subject and how it ties in to the life of the community he is likely to be a success if he knows how to appraise the class room accomplishment of his students. I have always felt that a good teacher should rarely fail a student at the end of the term. If a student is failing it should be obvious as the quarter progresses and he should first be warned and then removed from the class long before the end of the period. We fail in this because in nearly all of our engineering classes it is hard work to keep such close track of student accomplishment.

A teacher who devotes the whole period to lecturing and assigns outside reading exclusively has no means of measuring student progress until the final examination. Outside problems which

lend themselves to coöperative effort on the part of students, while apparently helping measure progress, are frequently misleading. A computing number assigned to each student and used to vary the problem for each student is helpful in securing individual work outside of class.

Individual or party laboratory problems are a better guide in grading results than a single problem for the whole class. Laboratory design problems based upon the student's own field work are more inspiring than assignments based upon data gathered by someone else, especially if the latter have been used by several preceding classes.

This matter of grading fairly is one of the hardest problems the teacher faces. One sure help to a fair appraisal of the student is to use your eyes in the class period not to watch a book or notes or outline, but to look your students in the eyes. If you call for a recitation your question should be addressed to the whole class and then when you are sure the question is understood you can name the individual who is to recite. If you name the individual first, the rest of the class may not concern itself with the necessary thinking you are trying to incite.

If you know your program for the day you need not confine your attention to notes or hesitate in pushing the lesson through for economical use of the period. A thoughtful teacher knows that when he wastes a few seconds of time in class, it is multiplied by the number of students in the class and detracts, about as the square of the time lost, from the effectiveness of the presentation.

AIDS TO THE LECTURE SYSTEM

By B. L. ROBERTSON and T. A. ROGERS

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Introduction

By far the great majority of the classes in the technical courses in engineering in this country have enrolments which are relatively small, and are really of minor proportion when compared with the usual large sections in history, economics, philosophy, etc., in the liberal arts colleges. That is, whereas the section enrolment in these latter classes may, and for many normally does, reach into the several hundreds, the student group in the average upper division engineering course will be somewhere betwen 10 and 35. Even in the large engineering colleges it is quite common to find sections definitely limited to 25–30 men in practically all technical courses.

On the other hand, in a few universities, engineering courses are not divided into sections but are handled in exactly the same manner as the liberal arts classes. Registration is restricted neither in required nor in elective studies, and the instructor for any course must of necessity take all who ask for the work, his section being the only one. Because of this it is possible for an instructor in the beginning course in electrical engineering, for example, to have as many as 125 junior students, for classes in electrical theory for non-electricals to be approximately as large, and for senior courses to contain from 60 to 120 men. Basic courses in mechanics may be limited only by the size of the room, or because of general difficulties in schedule as related to other classes.

The relative merits of the small section *versus* the large class will not be discussed here—they probably are quite apparent to the reader. From an educational point of view alone it never is to be doubted that the training received in the smaller group is superior. Such has been the expression given in the past in this Journal, and is the opinion of those who have had occasion to work under both systems. The fact remains that mass instruction in large units is the problem which many have to face, the problem arising out of the great number of students, limitations on funds for increasing teaching staffs, restrictions on space, and difficulties in schedule. This article is written to present a few methods, particularly that of class response, which may be used to aid the handling of large technical groups.

The Lecture System

The large class means the lecture system in instruction. Recitation of any sort is practically out of the question because of restriction in time and loss of class interest. Progress would be extremely slow. The lecture method is fairly well known and should not need definition, but a few words may be said concerning it. In general, it involves on the part of the instructor 50 minutes each period of concentrated effort, an academic presentation of material which he has assembled, and a formal expansion, by himself, of the major ideas to be discussed. The problem in lecturing to a large class is that of putting ideas across and making them stick; hence the requirements on the instructor may be more those of good pedagogy and psychology rather than technical ability. Lecturing on technical subjects to a group of 100 students is more than formal platform speaking of a descriptive nature before a general audience, college or otherwise. It is neither merely talking the subject matter nor giving only a discussion of technical facts and data.

By far the hardest demand to meet at times is that of 100 per cent attention during the period, and the larger the class the more difficult of fulfilment this becomes. Attention is to be concentrated on the instructor because under the lecture system he essentially is the active one in the room, the student being entirely passive. With absence of recitations or board work events must follow a well defined prearranged program, and time is not available simply to let matters take their course or to carry out too many unpremeditated discussions except at the expense of loss of class interest. Those who have handled both the small recitation or discussion section and the large lecture class realize that the pressure, physical or otherwise, on the instructor under the latter method is more severe. Perhaps the greatest limitations on the lecture system are those of absence of individual contact between instructor and student, lack of opportunity to observe individual effort, and the tendency for the instructor to conduct his work in a purely impersonal manner with the attendant hazard of loss of pleasing personality while before students.

So far as the student is concerned it is supposed that in class he attentively listens, critically follows the presentation, takes selected notes (written or mental), and copies certain required formal derivations of a nature not found in his textbook. Out of class presumably he thoughtfully revises his notes for the educational value he alone will derive from that process, reads the course assignments and supplementary material, works the problem sets, and perhaps prepares a memorandum on questions he desires to have answered, which he will ask during consultation periods because of

lack of opportunity to raise his questions in class. Some instructors object altogether to any interruption during the hour.

Aids to Lecturing

One may aid his classroom presentation in many ways and thereby overcome, to a considerable extent at least, some of the difficulties just mentioned. The majority of methods of assistance are purely common sense devices attending good teaching, and would occur naturally to an instructor. A few others to be noted, however, may be somewhat new in aspect, and are schemes which the writers have been developing over a period of some time. The methods have been successful, and hence are given here for what general benefit they may be to others who teach large classes.

The entire list of teaching aids may be classified roughly into three groups: *Personal Presentation, Technical Methods,* and *Principles of Teaching.* All of these are apart from the technical knowledge possessed by the instructor, which, of course, is fundamental to everything else.

Personal Presentation

Personal presentation has to do with the appeal which the instructor as an individual makes to the class, much of his success depending directly upon the manner in which he handles himself before his students and the way in which they receive him. Among those items of a personal character which might be listed are neat dress and appearance, posture, bearing, voice, and manner. Good English, diction, and enunciation, together with proper voice inflexion are assets to be prized highly, and of inestimable value are good nature and humor. These qualities are essentially those first noticed by personnel officers during interview and should apply to the teacher as well.

Technical Methods

Under this heading are several points, which although they have in some respect a bearing upon the problem of teaching as such, nevertheless are sufficiently distinct to warrant separate mention as a group. One of the first is the injection of practical examples into the study, both to illustrate specifically textbook theory and to enlarge the scope of the application of the principles treated. Engineering applications always are most welcome and are stimulating to an extreme not obtained in any other way. However, coined examples do not suffice—they too quickly lose their appeal. It is far better to use a few actual illustrations now and then than very

frequent problems of this nature which have been made up. The writers have found that application articles in the *General Electric Review,* the *Electric Journal,* and *Electrical Engineering* are admirable for classroom discussion, and in addition to technical features present highly desirable economic aspects of engineering. A very large part of the year of study in a 3-hour a week class of non-electricals which the writers conduct is devoted to the relationships between the so-called textbook theory and actual engineering problems of the types found in these journals.

Closely allied with the method of using applications, which are part of the experiences of others, is that of introducing similar personal experiences of merit, if presented modestly, and if not too old. And of comparable or greater value on occasion is the bringing in of practicing engineers to discuss the general and specific phases of their work as it relates to the subject at hand. It has been found best in this respect to coördinate closely the talks with the course outline, to the end that these men may leave a few problems which can be assigned at that time to the class in sequence with the regular studies. The instructor later is to take up the discussion of them.

Inspection trips, when feasible (but rather difficult with large groups), are of great value to those who go, and raise many points which later may be considered advantageously by the class as a whole. Occasional slides and moving pictures are of merit. Moving pictures on many subjects readily can be secured, and when preceded and followed by some class discussion have been found to be well received. Also, lecture demonstration apparatus of simple nature, given when introducing new principles, is extremely beneficial. Seeing a small half-inch ball bearing go around and around inside a six-inch stator under the influence of a three-phase field does more to portray the revolving magnetic m.m.f. of the induction and synchronous motors than any amount of mathematics can possibly do. It is one of those few times in electrical engineering when the student believes he is able to see what he is talking about, and as yet it never has failed to bring forth prolonged interest.

Principles of Teaching

Those things, which by observation and direct student comment, stand out in the minds of the writers as highly significant in methods of teaching begin with a display of enthusiasm by the instructor for the field of his choosing, a rather intense feeling for the subjects he is presenting, and the indication of a sincere desire to convey his story to the class. Such efforts lead to a certain amount of animation, the stimulating effects of which invariably react favor-

ably upon the students, and distinctly leave the knowledge that the material is given because it is something they will need to know. Lectures without such force too often merely carry the impression that the discussion involves subject matter offered simply because it is customary to give it, or because "it is good for them (the students)." Ideas imparted perforce of either argument have not been found to stick.

Obviously, such methods of classroom presentation will carry with them a certain air of self-confidence on the part of the instructor, and the appearance of mastery of the subject. Both of these qualities, modestly sustained, are highly desirable. It never should be forgotten, however, that teaching really is a collective undertaking. An instructor is not required to know everything about the course he is giving, and perhaps it is better that he does not.

Talking directly to the class in a conversational tone of voice whenever possible has been found conducive to attention, with the additional benefit of less physical exertion on the part of the instructor. Keeping continuity of thought by means of a few words review at the beginning of the period, and a brief statement given at the end of the hour on the topics of the next period, also serve to focus attention on the developments considered. With similar aim, the smoothness of the discourse is enhanced by transitional comments when stepping from one phase of a subject to another, or when the lapse of a few seconds in the more formal presentation may be required. Of course, any apparent stress on class attention should never imply a tense and rigid attitude of the student because ease of mind and body are essential to good reception. A pleasant and good-natured manner, with clean humor when the situation allows or demands, is quite helpful in relieving any tension.

But little technical engineering can be followed up out of class without at least a few well selected notes taken during the hour. Some instructors discourage note taking to any extent, preferring to have their sections listen only, but it is felt that the majority of teachers are rather of the opposite faith and encourage concise and well appearing observations on their discussions. The junior student, just beginning his studies in his major department, usually has had no training whatever in this direction, and if not guided later will show his instructor an assortment of marks which neither can decipher. (One often is quite surprised to see on paper what he is supposed to have said in class.) Hence, perhaps to consider a few well directed remarks at the start of the semester on the value and method of taking good notes is not amiss.

It also is beneficial periodically for the instructor to have the class critically follow the discussion. Later he can point out those pertinent items which might well be recorded. Time is never so scarce that this cannot be done. Lecturing should be a second approach to the subject from that of the textbook or syllabus, and therefore a concise set of notes becomes an abbreviated outline. It greatly strengthens the fundamental reading matter of the course and becomes more directly applicable to the instructor's problem sets and general requirements.

Class Response

The principle of teaching which has proved most effective and of greatest interest in its development is that of class response. The discussion of it more properly belongs to the above subject heading, but the method is of sufficient importance to set it apart. Because of the good results achieved, general student participation, and commendation, considerable effort has been spent in its perfection. The scheme has been in use for several years and has been of such aid to both the class and the instructors that it is presented here for the interest of others.

Briefly stated, the method undertakes to awaken group interest in class, and thereby to stimulate also study out of class by allowing student participation in the developments given during the lecture hour. This participation consists mainly in answering spontaneously, by any of those who may care to respond, leading questions posed by the instructor. The questions are directed to the class as a group, and involve such things as recalling principles of physics and engineering, definitions, what next step appears logical, why it is to be made, in what manner it shall be made, and to what extent or how much.

Questions are both qualitative and quantitative in character, may be given at any moment, and may pertain to any phase of the work as it logically is being treated. The questions are entirely spontaneous, with no prearranged list or cut and dried mode of attack, in order that class attitude may become as informal as possible. The method borrows heavily from the small recitation section, but rarely is a particular individual called upon to assist the discussion. As one begins to know his students, informally he may single out certain ones at times for comments, or as he recognizes voices he may follow up particular answers by momentary acknowledgment of those persons.

The number of students who respond will vary greatly, depending mainly upon the question. Some times only one or two answers may be received, and again the entire class may reply. In gen-

eral, just as soon as the proper answer, or what is sufficiently close to it, is heard, the instructor resumes his discussion until another worthwhile question presents itself. The instructor never dwells on obvious points. Unanswered questions preferably call for some small bit of comment until the class is brought into an understanding of the desired result rather than the instructor's answer. It probably is better to digress very briefly now and then, if the occasion warrants, than to hasten on with the class not in step. On the other hand, time is valuable and a discussion of any kind must not drag or be burdensome. For the most part it is possible, if handled well, for the running discussion to cover fully as much ground as though the material were formally given.

To the extent at least of student participation in the class study, the method decidedly is at variance with the formal lecture. However, the underlying point is this: it is one thing for the instructor to go through a logical development by making one statement after another on the methods and the whys and wherefores of the subject—it is quite another thing for the student to take part in that development. In the first case the reasoning is that of the instructor alone with the student purely a follower. In the second instance the student keeps more abreast of the instructor by contributing some of his own thoughts, incorrect though they may be at times. The student builds up a method of thinking similar to that of the instructor, catches his philosophy of approach to the problem and takes a hand in the development of the study by what analysis he can add while the subject is entirely new. Primarily it is an opportunity for student activity and the student plays the game with the instructor rather than being but a side line observer.

Without further discussion, but placing the advantages of the method in more compact form, it may be said that class response

(*a*) may be used in conjunction with lecture classes,
(*b*) may or may not request specific individuals to assist the presentation or to add ideas to the class discussion,
(*c*) unifies class thought on the direct questions proposed,
(*d*) makes for greater attention during class,
(*e*) stimulates student thought during the hour,
(*f*) stimulates the student to do better work outside of class,
(*g*) allows for individuality which psychologically has a very favorable reaction on the student because he feels he is taking part,
(*h*) keeps instructor's interest alive as well as that of the class (there are mutual benefits which enter here),
(*i*) allows an estimation of student attitude toward the subject material and the manner in which it is being accepted together with the speed of reception,

(*j*) allows an estimation of individual ability and personal observations in a quiet way which aid in determining the semester grades,

(*k*) serves to drive home specific points which otherwise might become submerged in the more formal presentation,

(*l*) requires thinking in terms of ideas rather than symbols, i.e., avoids mechanism because it is usually a question of "what next and why,"

(*m*) may require less obvious notes on the part of the instructor,

(*n*) eliminates mechanical recitation, which could not be carried out anyway with a large class, yet obtains equivalent results so far as the student is concerned,

(*o*) indicates to the slower students the better thinking of the quicker ones, and also may indicate the need of self-improvement together with those parts of the course on which such improvement is needed; may in addition indicate certain easy methods for the student to use in assisting himself in his outside study time,

(*p*) has the aspects of a game now and then in which the student attempts mentally to keep in step with the instructor. It livens the class, increases interest, and makes for good attitude toward the course. (If a student does not like a course, or an instructor, he will not work on the course no matter what the instructor may do. Our job as teachers, particularly with those below graduate years, is mainly one of psychology. If we can arouse a student's interest he will do the rest with only fair coaching),

(*q*) should have no grades associated with the classroom comments by students,

(*r*) takes but little more time than the more formal lecture but is quite apt to be much more effective in the number of ideas per hour which actually are grasped. Three ideas grasped each period are far better than twelve stated but not understood, and

(*s*) promotes friendliness between class and instructor and allows the instructor to become better acquainted with his class.

THE TEXTBOOK QUESTION

By R. C. BRINKER

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A recent engineering textbook advertisement divided texts into two classes, first, those books which "strike intellectual sparks" from their readers, and second, those which "spoon feed" their perusers. The text being advertised was placed in the former class as one which caused the reader to dig out the material covered. For this reason, the text apparently was considered superior. Without endeavoring to generalize on the respective merits of texts of either class for all courses, the intent of this article is to indicate that in certain courses, texts of the spoon feeding type—or more particularly mimeographed notes serving the same purpose—do give more satisfactory results.

Also, many text advertisements use the number of pages and the broad field covered as selling points. From the viewpoint of the student who pays for the text prescribed for a course, some question may be raised as to the necessity of buying more material than is needed for that course. These two questions of type and coverage of material in textbook presentation should be subjects worthy of faculty consideration.

The University of Minnesota requires some engineering students to take a one-quarter, short course in surveying. This eleven weeks' course naturally covers only fundamental transit, tape, and level work, with a small closed traverse and some topography, which is computated and platted. Strangely enough, not a single short course text could be found that covered these fundamentals completely and satisfactorily, such vital points as computation of bearings and adjustment of a level circuit being conspicuously absent. Some of the more expensive texts could have been recommended, but it was felt unwise to force a student to buy a book of which only a small portion would be used. As a matter of fact, when a large text was prescribed, few students purchased one. Consequently, a set of mimeographed notes has been substituted for a text, these notes covering in detail the actual work covered, at a cost of but a fraction of the price of the cheapest book. Needless to say, the students find direct answers to many of the questions which face them the first time they handle an instrument and easily digest this spoon feeding. Experience indicates that providing notes which are easily interpreted has not lowered the standard in any way.

Mimeographed notes were also used this year to replace temporarily the text for one of the advanced structural courses. In this course, as in most others, it was found that the average student will not read a book in order to discover things for himself. The student demand in all structural courses seems to be for a straight theoretical lecture (with no trimmings) and a considerable number of examples. The cost of a text in which there are enough suitable examples worked out and diagrams to satisfy the students is almost prohibitive.

The mimeographed notes used covered the lecture material in complete detailed form and were followed by the solution of one or two typical problems, with suggested or practice problems also listed. During the lecture periods, the theory was covered and additional examples worked. Because of the detailed coverage in the mimeographed sheets, students took no notes thus eliminating divided attention which is fatal in most courses. References to various texts were given in the notes, thereby providing a source of additional examples and variations in theory for the more ambitious student.

The student reaction to this method of teaching was very favorable. Without question, the students understood the material covered as well as any class that had to expend much more effort supplying missing steps in proofs and problems. In defense of spoon feeding and limited reference work, let it be said that many faculty men, who know their subjects very thoroughly, little realize the time required for the average undergraduate student to pry from unresponsive texts enough knowledge to pass half a dozen courses carried simultaneously.

The question may be raised that some future reference will demand possession of a text covering a greater field than that covered in mimeographed notes. Texts of almost unlimited scope and size are available in any technical library or office to satisfy this need. Most of these books should be called reference books for they are not truly undergraduate texts in the full sense of the word. Admitting that it is easier to find material in a text one is accustomed to, if that part of the book has not been previously used, any book will do as well. Furthermore, every student will have the mimeographed notes for reference, whereas under present conditions only a fraction of the class purchases a voluminous text. Students should be encouraged to start their own libraries, but not with books which will shortly become antiques in their fields.

The changing of texts (which usually elicits remarks from students as to the percentage cut received by the faculty from the bookstore for so doing) can be eliminated in some courses by providing the fundamental material in note form, and covering new

or other desired material by lectures and references, or by supplemental notes.

It is probable that some of the present texts were developed from the type of notes mentioned. However, additions and generalizations, causing the omission or condensation of the details required for clearness on the premise that every text should be a complete reference book, or that some school might use the book if a more or less related feature be incorporated, requires students to buy unneeded material at a time when they have no us for it, or to purchase duplication of material appearing in previously obtained books. For example, students purchasing successively, mechanics, stresses, and concrete texts, find the three moment equation religiously covered in each. Previously, in buying mathematics, surveying and other texts, the student acquired several sets of log tables.

Undoubtedly, too many texts, written for use in a particular curricular arrangement, or written to cover a general field, are used in courses for which they are unsuited. For best results, texts must be made to follow courses, not courses to follow texts.

SUPERVISION OF ENGLISH COMPOSITION IN THE UPPER CLASSES AT PURDUE UNIVERSITY

By F. W. GREVE

Professor of Hydraulic Engineering, Chairman, Committee on Standards in English

The first step to stress the importance of English in all curricula at Purdue University was taken in 1915 when the faculty added the following provision to the University code: "Junior and senior students, shown by test papers, reports, and recitations to be markedly deficient in English, shall be referred by Schools and departments to the English Department for examination. Such students shall not be considered candidates for graduation until their English is certified as satisfactory. It shall be the duty of instructors to report to Heads of Schools or departments students who are unsatisfactory in English."

A special committee on standards in English, under the direction of a member of the Department of English, was later appointed to execute the faculty mandate. All teaching members of the University staff were solicited to forward to the chairman such student papers as were defective in composition. The writers of these papers were later requested to confer with the chairman, who in person carried out the committee program. Many of the students' faults were caused by carelessness, which could be corrected in conference. In other instances the errors were fundamental and necessitated additional personal instruction by the chairman.

The program arranged by the committee failed to prove effective for two reasons: first, because most members of the teaching staff did not for one reason or another coöperate with the committee; and second, because no mechanism had been provided to inflict the penalties set forth in the new section of the code. The only way in which an upperclassman judged guilty of illiteracy could be penalized was by faculty action upon recommendation of the committee. No such recommendation was ever made. The chairman achieved excellent results in his personal contacts with delinquent students, especially so in view of the meagre support accorded him by the staff.

About a year ago the faculty decided to take drastic action with respect to delinquency in English among upperclassmen. Accordingly the code was again amended to read: "Junior and senior students who are markedly deficient in English will have their names

certified to the Registrar by the Committee on Standards in English. They will then be assigned to a non-credit course, which they must pass before becoming eligible for change in class standing or for graduation." The committee was reorganized to include a chairman, a secretary, and one representative from each of the ten schools and independent divisions of the University. President E. C. Elliott, acting upon the request of Professor H. L. Creek, head of the Department of English, appointed the writer to the post of chairman. The appointee to this position, in the opinion of Professor Creek, should always be a faculty member of some department other than that of English.

The reorganized committee, provided with a generous budgetary appropriation, complete office equipment and facilities, the half-time services of two readers, and a part time clerk, began to function about March 1, 1934. The two readers, Mr. H. B. Knoll and Mr. A. E. Koenig, were selected from the staff of the Department of English as was the secretary, Professor J. H. McKee, who devotes about one-fourth of his time to the position. The execution of the committee's policies was placed in the hands of a subcommittee composed of the chairman, the secretary, and the two readers.

The committee formulated the following general policy in the belief that the principal cause of delinquency in English among upperclassmen is carelessness, which can be eradicated to a large extent by occasional supervision over student written exercises.

1. Reliance upon voluntary coöperation of the instructional staff should be abandoned.

2. The heads of schools and independent divisions should be requested to forward a given number of class exercises from each junior and senior student.

3. Upperclassmen should be examined for performance rather than for ability.

4. Specimens of student composition written as part of normal class exercises should be examined for illiteracy.

5. At least two specimens per semester, and as many more as time would permit for reading, should be obtained from each upperclassman in his or her scheduled courses.

6. Additional unsolicited specimens submitted by individual instructors should receive the careful attention of the subcommittee.

7. Students whose composition in course work was found unsatisfactory should be further tested as to their command of the written word.

8. The policy formulated by the committee should not apply to seniors until September, 1934, because of the short period of time intervening before graduation.

The courses from which specimens were obtained were selected by the heads of schools and independent divisions. The specimens, written in class, were of several different types and included recitation, test, and examination papers, and laboratory reports. Some of the unsolicited student papers submitted by a few instructors were prepared at home. The members of the committee were charged with the responsibility of forwarding all papers to the central office. The clerk attached a sticker to each specimen upon its receipt at the office, following which operation the paper was routed along a definite channel back to the point of issue. The name and address of the committee was printed on each sticker, which was of sufficient size to permit notation of the receipt and return dates, the reader's name, and the reader's comments. Specimens which were satisfactorily composed were returned direct to the proper committee representative. All other papers were held at the office until the respective writers thereof had appeared for a conference and an examination.

The number of specimens read subsequent to March 1, 1934, totalled 1,360. In many instances only one specimen instead of the desired two was received from a junior. Summonses were sent 143 juniors to appear before the subcommittee for examination. The time allotted for an examination was one hour, and it may be mentioned in passing that not a few students were mentally exhausted before the expiration of sixty minutes. The nature of the examination was changed from time to time. Usually the student was asked to write on some general topic, such as summer employment, course work, travel, athletics, etc. Each examination paper was read by the four members of the subcommittee in order to forestall criticism which was certain to ensue were the judgment of a paper left to one reader. It is an interesting and at the same time disturbing fact that of the 143 students summoned for examination, 15, or almost 10 per cent, entered the University with credit in English from some other institution.

A total of 52 students, approximately 37 per cent of the students examined, were found markedly deficient in English, bearing out the committee's belief that much of the illiterate writing by upperclassmen can be attributed to carelessness. It is to be inferred, therefore, that some instructors in departments other than that of English, are remiss in accepting "sloppy" writing. No action was taken with respect to juniors who had not yet completed in the Department of English their required course work in composition. Delinquent students, those who failed to pass the subcommittee's examination, were advised to attend a special class in composition which met weekly under the personal supervision of Professor McKee, secretary of the committee. Attendance was vol-

untary and 33 of the 52 delinquents availed themselves of the opportunity, many of them at irregular intervals. Seventeen of the class were found by the subcommittee to have shown sufficient improvement in their writing before the close of the semester to warrant dismissal from further consideration.

The names of 35 juniors, representing about 4.2 per cent of the junior class, were certified as being markedly deficient in English. These students have been denied senior classification until they shall pass a semester's work in a special, non-credit course in composition under the instructorship of Professor McKee. It is quite possible that a few juniors were absent from class on the days specimens were collected. Now that specimens are being forwarded to the committee twice each semester during both junior and senior years, it is hardly conceivable that no specimen will be received from an upperclassman prior to graduation. However, the bare possibility that an upperclassman will escape the committee's scrutiny will continue to exist unless funds for the committee's use are increased beyond the limit of profitable return.

The subcommittee as a whole acted upon all assignments to and dismissals from the special classes provided for delinquents. During the last three months of the past semester, the subcommittee devoted on the average about six hours per week to student conferences, in addition to the reading of 260 examination and other papers written in the special classes. The number of papers to be read during the present academic year will approximate 4,000.

The committee believes that its work has indeed been profitable. Not only has it succeeded in weeding out for additional instruction in English certain upperclassmen guilty of illiteracy, but, more important still, it has focused the students' attention upon the wisdom of careful writing.

The following excerpts exemplify the types of illiteracy discovered by the readers in the specimens submitted from course work.

1. "Criticle debth is the depth to which warter must remain to remain in the stable condition."

2. "Sardinia was a fertilized state."

3. "The enerita of the water was measured on a preasure gage."

4. "The Bourbon Gague."

5. "Timber is resistant to decay in a region where there is very little moisture under water."

6. "A baby at birth cannot memorize because he has not had previous experience."

7. "The child should have a cat her own size so that she may rest well after meals."

8. "Trees grown in the open. Because trees grown in the forest have their lower branches broken or decayed off thus forming knots

throughout the trunk of the tree that is as the tree grows on more lower branches are formed and the process is repeated."

9. "Short anemia experiments have indicated that spinach is favorable to production of red cell and hemoglobin, fresh or canned."

10. "A native trait is the one distilled in the baby or the newly born."

11. "A law as meant the law of conservation of mass is an existing condition which man has discovered to be true and to which he can do nothing to change it."

12. "Resposible. Supperior. Artilery. Attendence. Maner. Theorically. Pracital. Cappable. Site (cite). Principal (principle). Mean (means). Mearby. Speeker. Exgerated. Hypithecial." These modified versions of the English word appeared in a single paper written by a junior.

13. "It helps give every student in School a chance to take part in sports if he wants it also give those a chance whom are not physically giften as others. It also takes in a large range of sports and such a variety that will appeal to any red-blooded American boy and give him a chance to partacipatl in these sports as a relaxation from his daily routine in class. It will give me a knowledge of the game, how to teach, when and where to play it and to what time of people play these games. Any one who wants to teach Phys. Ed. must have complet knowledge of Intramurals cause they are the coming thing and this is my honest opinion. The metting of new friends; getting ideas of different people and friends he knew because in a sport when one is key up, he portrays his true character and and in these sport it make ups the daily routine of College life more interesting."

CONFERENCE ON COÖPERATIVE PLAN OF EDUCATION *

EVALUATION OF COÖPERATIVE ACADEMIC CREDITS

By H. H. METZENHEIM

Newark College of Engineering

Summary

The paper calls attention to the lack of uniformity in the meaning ascribed to such common terms as: School Year, Term, Semester, Semester Hour, Credit Hour, Credits, Hour and Period.

A new unit for measuring the quantitative element in academic credits is proposed. This new unit is the 1,000-minute unit or the kilo-minute of time devoted to actual instruction in classroom or laboratory.

In comparing curricula and time devoted to instruction in a few representative coöperative and non-coöperative engineering colleges it was found that the coöperative school programs assigned as much or more time to academic instruction as the non-coöperative schools.

The paper advances the idea that coöperative colleges base their evaluation and accrediting of degrees given by them upon the academic content of their courses, and that they maintain their position regarding the industrial field experience for undergraduates as an extremely valuable and necessary part of educational procedure.

NEW APPRAISAL OF THE COÖPERATIVE PLAN

By P. EVANS COLEMAN

Summary

Beginning where the committee headed by W. E. Wickenden left off in 1926 Dr. Coleman has completed a six-year case study of the coöperative versus the traditional plan. He found that a basic generic condition of student employment similar to what is authoritatively recognized as widely prevalent in American colleges. He found that 60 per cent of the traditional college students averaged 25 months net time of employment between college entrance and graduation, which is only slightly less than the prescribed amount for the coöperative student. But the latter's time is better

* Held at Cornell meeting S. P. E. E., June 20, 1934.

planned. His student employment is practically all contributory to the educational aims of the curriculum, whereas scarcely one half of the traditional college student employment was thus contributory. Coöperative students take no longer or little longer to complete their undergraduate course than the conventional type. The average age at graduation for the former was 23.8 and for the latter, 23.2 years. Coöperative students progress through their student employment to jobs of greater responsibility, for their work is better planned. In times of depression, the coöperatives hold their positions better. The alternation of school and field work produces superior conditions for effective learning. The coöperative plan is not only more efficient but more democratic. The fathers of students in the traditional type college of this investigation were in occupations with approximately twice the opportunity and contacts to induct successfully their sons into business executive levels. These advantages of parentage were recently well established by Taussig and Joslyn in a study of 10,000 American business leaders. The coöperative plan tends to offset some of these advantages.

HISTORY AND PLAN OF OPERATION, GEORGIA SCHOOL OF TECHNOLOGY–CENTRAL OF GEORGIA RAILWAY CO-OPERATIVE-ENGINEERING COURSES

By T. A. JOHNSON

Central of Georgia Railway Co., Savannah

History

The History of the Coöperative Plan of Education with the Central of Georgia Railway is indeed very interesting. In 1923, Mr. L. A. Downs, Vice-President and General Manager of the Central of Georgia Railway, later our President, and now President of the Illinois Central System, realized the need of college men in the Mechanical Department of the Railroad, and established in conjunction with the Georgia School of Technology, a Coöperative Plan of Engineering Education and effected an agreement with the School whereby students who were doing unusually well in their college work were selected from the Mechanical Engineering Courses for employment in the shops of the Central of Georgia Railway. The plan was carried on by Mr. Downs' successors, Mr. J. J. Pelley now President of the New Haven; the late Mr. A. E. Clift, and the present executive Mr. H. D. Pollard.

The coöperation between the railroad and the school was so satisfactory from every standpoint that more students were added as the

opportunity presented itself for additional employment. At no time since the beginning has there been any inclination on the part of either the Georgia School of Technology or the Railroad to discontinue or abolish the plan. However, during the past four or five years employment of students was curtailed due entirely to the general decline of business, and I am happy to announce that as soon as business began to show an increase, the employment of students was increased proportionately.

The original idea of our Management in subscribing to this plan of education was twofold, and naturally was based on the assumption that the benefits derived from such a course would be mutual to employe and employer alike:

1st. From a humanitarian standpoint it would offer an opportunity to ambitious young men of our territory to secure a college education who otherwise might never have an opportunity to do so.

2nd. It would bring a high class of young men into the employ of the railroad as apprentices, who would be taught in a comparatively short time to do good work, and upon graduation from their courses would enter our permanent employ and offer excellent material for advancement.

Experience has shown that the advantages of No. 1 have been fully realized; as to No. 2, by reason of decreased employment, due to decline in business, we were never able to absorb into our ranks the coöperative graduates to the extent that had been anticipated. However, we were not discouraged by this feature, for it was our experience that the boys who had been in our employ for five years remained our steadfast friends regardless of whom they might be affiliated with, and it is reasonable to expect that as time goes on and they become more mature, with greater responsibilities and higher positions, we will retain their friendship, a valuable asset to the railroad.

Efforts have been made to keep in touch with the graduates that were not retained in our organization; their careers have been described in our monthly publication, the *Central of Georgia Magazine,* and copies of the *Magazine* are regularly sent to them.

After these students are graduated our records show that they follow mechanical or electrical engineering professions or the kindred ones, some going with other railroads, some with industrials and utilities, and of course some remain in our Organization. At present one of the large railroads here in the East has three of these Coöperative Students, but the majority of them remain in the Southeast.

From 1923–1933 a total of 47 have completed their courses, graduated and joined the ranks of various industries. Insofar as we are able to ascertain every one of these boys now living is em-

ployed in gainful occupation, practicing their professions or the kindred ones. When one considers that industrials, railroads and utilities employ the majority of engineers, and the reduction of their payroll and the curtailment of improvements for the past five years, it is truly remarkable to find 100 per cent of these graduates gainfully employed and tends to prove that this system of education has much merit. Obviously in this period of—survival of the fittest—their services must be of a satisfactory nature.

Operation of the Plan

The Coöperative students are selected by the school authorities from the upper third of classes graduating from preparatory and high schools. After completing one or more school periods, meeting the scholastic requirements of the Georgia School of Technology, they are then required by the Railroad to stand a rigid physical and ocular examination. I might add that this is not simply a matter of formality; the road's physical and ocular standard is high—the scope of the examination is equivalent to the requirements for entrance into the U. S. Army or Navy.

Upon their acceptance they are given employment as special apprentices in one of our shops, and if practical, located in or near the students home town, to permit them to live at home, thus reducing their expenses. In reporting for work, the officer in charge of the plant assigns them to one of the several departments where they can be used to the best advantage; then changes are made from time to time from one department to another including machine, boiler, smith, pipe, car and electrical shops, where they are taught operation of machine tools, the manufacture and repairs to parts for locomotive and cars; also in the erecting shop where the locomotives are assembled, tested and prepared for service.

There are no rules governing the period of time spent in the various departments—sometimes the students are changed at their own request. It is understood by all concerned that these boys are to be given an opportunity to familiarize themselves with the various tools, processes and practices of each department. Due to the limited amount of work in the Testing Laboratory and Drafting Room only a few students in their senior year are given an opportunity to receive this training.

The course calls for alternate periods of class-room study and practical work, and requires five years for completion. While at work the students are paid regular wages, starting at a rate 3 cents per hour more than the regular apprentices and advancing 2½ cents per hour at the end of each six months. In addition to compensation, the coöperative students have all of the other benefits of rail-

road employment, such as group life insurance, hospitalization and free transportation to and from school. We have never received a complaint on the part of the students about their assignments. They assist with or do any class of work. We do not select soft, easy jobs for them. They are told at the beginning not to expect it. They are not afraid of work. They are from families accustomed to hard work. The students comply with all rules and regulations of the shops as do other employes, and are encouraged to and do take part in the social and political activities of the organization. The school furnishes us with a copy of their report card so that we may keep posted on their school grades. The records are checked by competent persons and if not satisfactory the students are encouraged to try to do better.

In order to create special interest in this work, the railroad established the plan a few years past of giving Central of Georgia certificates to those who had completed their five years training with the road and with the Georgia School of Technology. These certificates are awarded at Commencement Exercises of the School. This past Commencement, our General Manager Mr. R. R. Cummins delivered the certificates as a part of the program.

Benefits Received

During the working of the Coöperative Plan in the cold light of reason and putting aside any sentimental considerations, it is the opinion of the Management that the wages paid to Coöperative Students is money well spent. Boys seeking enrollment in the course are usually those who find it necessary to be at least partially self-supporting during their college years. It follows therefore that they have more than the average of ambition and energy. They bring to their shop duties the advantage of theory. Conversely they take to their scholastic studies the advantage of practical experience. Ultimately they become well rounded.

The requirements of the Georgia School of Technology are rigid and result in the early weeding out of the incompetent and indolent. The time waster and social butterfly cannot long survive in the strenuous atmosphere of the coöperative course. Those who have genuine stamina quickly develop real manhood and are reliable, intelligent and industrious employes.

MACHINE DESIGN CLEARING HOUSE

New Executive Committee for Machine Design Division

The following candidates who were selected by the special nominating committee have been elected: Professors V. M. Faires, J. M. Foster, C. W. Ham, E. MacNaughton, F. L. Eidmann. The committee has again selected F. L. Eidmann as Chairman.

This committee will also act as the advisory committee of the Machine Design Clearing House.

New Members

C. D. Billmyer, Rhode Island State College
P. A. Cushman, Valparaiso University
A. L. Townsend, Massachusetts Institute of Technology
R. S. Wilbur, Duke University

Membership List

The accompanying list includes the names of members of the Clearing House as of January 1, 1935. The names of all who owed assessments for two or more years have been dropped. We now have 77 members.

Financial Report

It is gratifying to note that 70 members have paid their assessment for 1933–34. Expenses for the year were $69.40. This is the first time that we have "broken even."

Lower Assessment for 1934–35

Due to having F.E.R.A. clerical assistance and also to the use of offset printing (which enables us to reduce four typewritten sheets to a single $8\frac{1}{2}'' \times 11''$ sheet, as in the December bulletin), we are budgeting on the basis of an assessment of 50 cents per member.

The assessment is NOW DUE. Why not pay $1.00 now for two years?

Machine Design Conference at Atlanta Meeting

We have requested two sessions on Monday, June 24, at the Atlanta meeting of the S. P. E. E. Four papers will be presented. We hope to have the abstracts for the May bulletin of the Clearing House.

A New Textbook

Professor C. E. Pearce, a member of the Clearing House is the author of "Principles of Mechanism" recently published by John Wiley & Sons.

Discussions are Welcome from Non-Members of Clearing House

It is hoped that the Clearing House bulletin is passed on to your colleagues. Invite them to discuss the topics and also to make suggestions.

Frank L. Eidmann,
Chairman

Membership List—Machine Design Clearing House

E. S. Ault, Case School of Applied Science
G. C. Autenrieth, College of the City of New York
G. M. Bartlett, Purdue Univ.
F. S. Bauer, Univ. of Colorado
J. H. Billings, Drexel Inst.
C. D. Billmyer, Rhode Island State College
L. Blumberg, Univ. of Delaware
T. G. Caywood, Univ. of Iowa
W. H. Clapp, California Inst. of Technology
W. J. Cope, Univ. of Utah
P. A. Cushman, Valparaiso Univ.
R. B. Dale, Pratt Inst.
A. J. Diakoff, Univ. of North Dakota
L. O. Doerr, North Dakota Agr. College
V. L. Doughtie, Texas Technological College
A. M. Dudley, Westinghouse E. & M. Co.
S. F. Duncan, Univ. of Southern California
W. V. Dunkin, Georgia Sch. of Technology
J. R. DuPriest, Univ. of Minnesota
P. B. Eaton, Lafayette College
F. L. Eidmann, Columbia Univ.
V. M. Faires, Texas A. & M. College
G. W. Farnham, International Textbook Co.
H. H. Fenwick, Univ. of Louisville
J. M. Foster, No. Carolina State College
F. Franz, New Haven College
I. M. Fraser, Univ. of Saskatchewan
G. J. Frey, Ohio Mechanics Inst.
E. F. Garner, Cornell Univ.
H. C. Gray, Rose Polytechnic Inst.
F. S. Griffen, Univ. of Akron

J. A. Hall, Brown Univ.
W. R. Halliday, Stevens Inst. of Technology
C. W. Ham, Univ. of Illinois
S. T. Hart, Syracuse Univ.
E. D. Hay, Univ. of Kansas
L. M. Headley, Johns Hopkins Univ.
H. C. Hesse, Univ. of Virginia
U. C. Holland, Rutgers Univ.
G. Immediato, Brooklyn Polytechnic Inst.
L. E. Jermy, *Machine Design*
C. C. Jett, Univ. of Kentucky
W. R. Jones, Oregon State College
G. B. Karelitz, Columbia Univ.
E. Kemler, Univ. of Pittsburgh
H. B. Langille, Univ. of California
O. A. Leutwiler, Univ. of Illinois
A. W. Luce, Lehigh Univ.
W. G. McIntosh, Univ. of Toronto
E. MacNaughton, Tufts College
V. L. Maleev, Oklahoma A. & M. College
J. V. Martenis, Univ. of Minnesota
G. H. Marx, Stanford Univ.
H. L. Mason, Taylor Instrument Co.
F. A. Mickle, Univ. of Michigan
W. S. McKee, Carnegie Inst. of Technology
R. W. Morton, Colorado Sch. of Mines
G. F. Nordenholt, *Product Engineering*
C. A. Norman, Ohio State Univ.
R. A. Norman, Iowa State Univ.
A. E. Norton, Harvard Univ.
H. L. Parr, Columbia Univ.
C. E. Pearce, Kansas State College
I. H. Prageman, Univ. of Maine
J. H. Pound, Rice Inst.
K. E. Quier, Pratt Inst.
M. F. Sayre, Union College
P. K. Slaymaker, Univ. of Nebraska
F. C. Spencer, Western Electric Co.
H. E. Stevens, Rensselaer Polytechnic Inst.
G. L. Sullivan, Univ. of Santa Clara
A. L. Townsend, Massachusetts Inst. of Tech.
R. M. Triest, John Wiley & Sons
H. A. Weiss, Clarkson Sch. of Technology
B. S. White, West Virginia Univ.
R. S. Wilbur, Duke Univ.
E. C. Willey, Oregon State College

Miscellaneous Discussions

The following discussions were received after the bulletins on the respective topics had been printed. We are indebted for these to:

E. C. Baker, Head of Mech. Eng. Dept., Oklahoma A. & M. College
F. S. Bauer, Prof. of Mech. Eng., University of Colorado
L. M. K. Boelter, Assoc. Prof. Mech. Eng., Univ. of California
W. V. Dunkin, Prof. of Mech. Eng., Georgia Sch. of Technology
J. Flodin, Assoc. Naval Architect, U. S. Navy (formerly on faculty of Univ. of Minnesota)
A. M. Greene, Jr., Dean of Eng., Princeton Univ.
P. J. Kiefer, Prof. of Mech. Eng., U. S. Navy, Postgraduate Sch.
O. A. Leutwiler, Head of Dept. of Mech. Eng., Univ. of Illinois
F. A. Mickle, Assoc. Prof. of Mech. Eng., Univ. of Michigan

On "The Suitability of Textbooks in Machine Design"

"I have appreciated for some time the deplorable absence of a text suitable for the grade of work that we, with many other schools, would like to present.

"I trust that the activities of your Clearing House may shortly elicit more adequate texts, built on the presumption of a reasonable student competence in mathematics and strength of materials, and proceeding to rational, intelligible and up-to-date analyses of particular and general design questions, tempered by frank acknowledgment and consideration of those items for which we must still depend largely on empiric methods."

"It is quite difficult to obtain a suitable text for a course in machine design. Most of the books published to date on the subject seem to have been written primarily for the course as offered at some particular institution, or they are more suitable for reference books. This makes it necessary for the instructor to supplement the text with additional notes, which is not satisfactory where two or more instructors teach the same courses. The writer realizes that the writing of a popular textbook on machine design would be a tremendous task due to the broad field which it covers, but on the other hand it would be a valuable asset to the teacher of machine design."

On "Which is Preferable in Teaching Machine Design—to Assign a Large Number of Unrelated Problems Each of Which Utilizes Some Major Machine Element, or to Assign One or Two Complete Design Projects?"

"It is the writer's opinion that the ideal machine design course should present the subject to the student from both viewpoints.

In connection with the design of the various machine elements the fundamental theory can be covered more thoroughly and quickly by a number of unrelated problems. The complete design and detailing of a machine involving a number of the machine elements previously studied not only unifies the earlier work but gives the student a chance to study design from the manufacturing side. Consideration of shop processes, limit dimensions, specifications and so on is just as important as theory. The average student will develop considerable interest and satisfaction in being required to carry through from beginning to end a job of this kind. He has something to show for his efforts. Only a fourth to a fifth of the time need be devoted to this unit problem. If the time for the course is limited the unit problem may be omitted entirely or at least sketches submitted in place of the scaled drawings."

"Machine design should be taught by assigning a large number of related problems which use different fundamental principles of design. The time allotted to machine design in college curricula is not sufficient to carry the design of a machine through to the finish without adopting 'rule of thumb' methods which have no place in the teaching field.

"Each machine element should be studied as to the loads acting on it and the stresses and deformations produced.

"A reasonably complicated machine should be chosen, with the power applied and the work done known, and a complete analysis made of all the loads, dynamic and kinetic, acting on every element. Consideration should be given vibratory stresses, the effect of repeated and reversing loads, the probable magnitude and importance of concentration of stresses and the standardization of the design of machine elements."

"Problems, selected from a wide field, containing fundamentals in design, are preferred. A general discussion on each problem, followed with analysis by the student, preferably under supervision, immediately followed by a similar problem, to be analyzed, independently, also under direct supervision, with no explanation, should equip the student with a working knowledge and practical application of principles. As time progresses, problems should become increasingly complex, gradually leading up to rational design. A minimum of detail drawing is desirable."

On "The Correlation of Experimental Laboratory Projects with Courses in Machine Design"

"The coördination of the undergraduate laboratory work in Mechanical and Electrical Engineering with the courses in machine design is to me one of the most important phases of the laboratory

program. The mechanical laboratories at this university are designed to illustrate the theory which is given in many courses, such as analytical mechanics, strength of materials, heat power engineering, thermodynamics, aerodynamics, automotive construction, fluid flow, hydraulics, etc.

"The first two semesters of the laboratory work are devoted almost entirely to experiments illustrating the fundamental theory underlying the operation of mechanical and electrical apparatus. An attempt is made to correlate existing information and to acquaint the student with the range of applicability of the fundamental theory. This is accomplished by illustrating several applications of differential equations, as well as to explain the theory underlying various criteria such as Froude's, Reynold's, Cauchy's, etc.

"The later semesters of the mechanical laboratories are devoted to application experiments. Of the experiments listed which are particularly valuable in machine design, I will cite the following:

1. Fluid flow applied to bearings.
2. Dynamics of reciprocating engine driven alternators or synchronous motor driven compressors.
3. Dynamics of speed regulation, flywheels or governors.
4. An experiment illustrating amplification, phase angle damping factor, and power input as a function of the ratio of forced to natural frequency.
5. Torsional vibration of an engine crankshaft.
6. Gyroscopic torque of a propeller.
7. Properties of welded joints.
8. Effect of heat treatment upon properties of metals.
9. Machinability of metals."

"I heartily agree with the suggestions which you have made.

"I feel that work in the laboratory, bringing out the principles of machine design, is just as important as work in connection with prime movers and heat transfer. I am delighted to know that you have brought this matter up for discussion. One of the most important problems along this line I feel is the investigation of speed regulation by means of flywheels and the checking of theoretical determinations from observations on actual machines."

"The writer is fully in accord with the view that more experimental equipment suitable for project work in machine design courses is needed in most mechanical engineering laboratories. The equipment in our own laboratories is quite limited, therefore we do not have organized courses in experimental projects of this kind. We do, however, make use of the general equipment to some extent for the purpose of observation."

On "Required Summer Work in a Commercial Drafting Room"

"Compulsory summer work is only too often somewhat of an odium to the student, and experience that he tries to go through with as little damage and as little profit to himself as possible. But if he starts out with such an outline of things to observe as you are giving, his entire attitude toward the task should be different. And, what is perhaps fully as much to the point, the men of whom he asks questions in order to get the information necessary for his write-up, will see in him a youth who is taking hold of life and will treat him more seriously than would otherwise be the case. This is particularly true in the larger industries and in times less stringent than the present. I have seen students, and even graduates during their first year of employment, treated in a manner that suggested a left-handed monkey wrench, plus the hope that they would not do any harm either to themselves or to the plant. But I have also seen an alert, inquiring attitude on the part of the student get him all the coöperation he could possibly want, and the report that you require should go far toward fostering such an attitude."

"I believe there is considerable value in such a requirement, in spite of some very serious objections and drawbacks.

"The student is apt to lose his respect for theoretical analysis and design unless great care is exercised in selecting his employer. It will tend to make a 'Handbook' or 'Rule of Thumb' designer and not an intelligent one. It would be impossible for industry to absorb all sophomore engineering students if all colleges adopted this plan. It would deprive many students of three months of remunerative work upon which earnings their future education may depend.

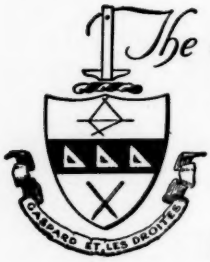
"The outline which you have suggested appeals to me as a very general training for a man as an engineer. It involves some design and drafting room procedure, with reference to standards, handling of blueprints and their distribution to the factory. It also covers an elementary study of plant management and plant arrangement."

"What do you do about getting summer jobs for your students under the present business conditions? And even in normal times do you think the plan would work with the large classes which we have in the state universities?"

"The best answer to the foregoing questions is the fact that at Columbia University all students in Mechanical Engineering are required to do summer work in a commercial drafting room (as outlined in an earlier bulletin of the Clearing House). The students find their own positions, which must be approved by the instructor. Some students are paid for their work, while others are admitted as 'observers.'

"The consideration and coöperation which is shown the students is most gratifying. It is likewise interesting and encouraging to find the students enthusiastic about the plan after having finished their work. As previously stated, these summer contacts sometimes lead to permanent positions after graduation. A recent graduate called on me last week and mentioned that he had received his present position, in competition with other candidates, on the strength of his summer work and written report.

"I realize the difficulty of placing large numbers of students but I believe the plan can be worked—perhaps in modified form—in most colleges."—FRANK L. EIDMANN.



The T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE DIVISION OF ENGINEERING DRAWING

FREDERIC G. HIGBEE, EDITOR

Executive Committee Meeting: In preparation for the annual meeting at Atlanta, and for the purpose of discussing matters of importance concerning the teaching and administration of courses in Engineering Drawing and Descriptive Geometry, a two-day meeting of the executive committee of the Division of Engineering Drawing was held in New York on February 2 and 3. The following were present: McCully (Chairman), Rising (Secretary), French, Farnham, Tozer, Ming, and Schuman (representing Warner). Among the topics discussed at the first meeting were: present trends in drawing; increasing requirements for drawing teachers; methods of producing better student drawings and the creation of a greater appreciation of quality drawing; the importance and cost of drawings in engineering projects; drawing courses as a prognosticating and orientation agency in engineering courses.

Considerable discussion centered around the best methods of raising the standards of the annual competition in engineering drawing, and of including in the competition a special problem following the general lines of the Beaux Arts Competitions. Following the discussion it was suggested that a special problem be added to the drawing competition which was to be drawn at the end of the drawing course under supervision by students who had had not more than one year of college instruction. A sketch of the problem would be required and submitted. Details of this special entry are now being worked out and information concerning it will be available for those who are interested.

Members of the Engineering Drawing Division are requested to notify the editor of the T-Square Page, giving pertinent facts, of articles and information of interest to teachers of engineering drawing and allied subjects.

SECTIONS AND BRANCHES

The third annual meeting of the **Pacific Southwest Section** was held at the University of California, in Berkeley, on December 27, 28 and 29, 1934, with an attendance of seventy members and guests.

Many of those present stated that this was the best meeting that the Section had had and were warm in their praise of the work of Professor H. B. Langille, of the University of California, who was chairman of the committee on arrangements. Professor A. B. Domonoske, of Stanford, chairman of the program committee, arranged an excellent program of papers, but, unfortunately, illness prevented him from attending the meeting. The number of papers was kept at a minimum, in order to give plenty of time for the discussion which all of them brought forth.

At the first session, on Thursday morning, presided over by Professor David M. Wilson, of the University of Southern California, chairman of the Section, Mr. Ward H. Austin, of the Marin Junior College, presented a paper entitled "Can the Junior College give the Necessary Work of the Engineering Course?" His paper answered the question in the affirmative. Professor John C. Park, of the University of Arizona, followed with a most interesting paper on "Methods." At the afternoon session, on the same day, Dean Charles Derleth, Jr., of the University of California, spoke a few words of welcome to the visitors on behalf of the University and then read a paper on "The Engineering Field." This was followed by a paper by Professor James C. Clark, of the University of Arizona, on "Employment of Young Engineers."

An informal dinner was enjoyed that evening at the Men's Faculty Club by the members and guests. Professor Emeritus Charles D. Marx, of Stanford University, one of the founders of the Society, had accepted the invitation of the Section to be the guest of honor at this dinner, but, greatly to the disappointment of all, a slight cold kept him at home. Professor Langille spoke of his distinguished career and of the esteem in which he has always been held by his associates and his students. Mr. Edwin A. Lee, superintendent of the San Francisco schools, delivered an edifying address entitled "Getting Down to Bedrock," in which he made a plea for the essentials in education.

At the Friday morning session, with Mr. Carlton E. Cherry, of Marin Junior College, presiding, Professor Lydik S. Jacobsen, of

Stanford University, gave a paper on "The Rôle of Mathematics in Mechanics," which was followed by one by Dr. Rudolph G. Minarik, of the University of California, entitled "Are We Teaching Engineering Mathematics?" Both of these papers aroused a great deal of discussion, which was very ably led by Professors G. C. Evans and E. C. Goldsworthy, of the Department of Mathematics of the University of California.

Friday afternoon was given over to an inspection of the engineering laboratories and, in the evening, an informal discussion on engineering drawing was led by Professor Floyd H. Cherry, of the University of California. Professor H. M. McCully, of Carnegie Institute of Technology, chairman of the Society's Division of Engineering Drawing, who was visiting in California, attended all the sessions of the meeting.

At the business meeting, held on Saturday morning, the following officers of the Section for the year 1935 were elected:

Chairman: A. B. Domonoske, Stanford University.
Vice-Chairman: John C. Park, University of Arizona.
Secretary-Treasurer: Franklin O. Rose, Modesto Junior College.
Executive Committee: The above and Eugene L. Grant, Stanford University; J. M. Robb, Taft Junior College; H. B. Walker, University of California; David M. Wilson, University of Southern California.

It was decided to hold the 1935 meeting at Stanford University, next December.

The entertainment provided for the visiting ladies by the ladies' committee, under the chairmanship of Mrs. Floyd H. Cherry, included walks around the campus, a drive about the Bay region and a tea and musicale at the residence of Mr. Franklin O. Rose.

The meeting was brought to a close on Saturday afternoon by a rather stormy but exceedingly pleasant trip, aboard one of the United States Quarantine tugs, on San Francisco Bay, to inspect the construction work on the San Francisco-Oakland and the Golden Gate bridges. A small group followed this with a walk through San Francisco's Chinatown and dinner at a French restaurant.

FRANKLIN O. ROSE,
Secretary-Treasurer

Are We Teaching Engineering Mathematics?

By R. G. MINARIK

Instructor in Mechanical Engineering,
University of California

I should like to say that the statements made herein are principally the results of my personal reactions. The stimuli for these reactions have been rather well distributed as regards time and place. They were encountered over a period of several years and manifested themselves at three universities and at several industrial establishments. I have endeavored to formulate my statements in the perspective of my experiences as a student, practicing engineer and teacher, hoping thereby to avoid unwarranted exaltations on one hand and accusations on the other. Although my sincere belief is that what I have to say is representative of conditions in most engineering schools and establishments, I should be somewhat surprised if I were not at least mildly controverted after Professor Goldsworthy opens the discussion.

First of all, what is engineering mathematics? Is it mathematics for engineers, applied mathematics, mathematics with an engineering tang, or something else? I doubt that an indisputable formal definition could be composed. A satisfactory concept of what most of us consider to be engineering mathematics could probably be obtained by contemplating the engineer's method of analyzing problems. Briefly, he is expected to:

1. Recognize a problem.
2. Analyze it in terms of fundamental principles or laws.
3. Express the analysis mathematically.
4. Manipulate the mathematical expressions until some definite objective (the "answer") has been reached.
5. Appreciate the significance and limitations of the mathematical solution.
6. Evaluate the solution numerically for the specific problem at hand.

Let us now consider this procedure in greater detail, noting particularly its mathematical components.

The recognition of engineering problems depends either upon circumstances which compel us to recognize them, or upon an inherent fascination and curiosity about life and all that it implies. I feel that we, the teachers of engineering students, are obligated to inspire in the student a romantic fascination, perhaps even sentimentality, for his chosen profession and thereby make even the commonplace a source of endless interest to him. There is of course always a shadow of impending disaster when we become

too romantic and therefore we must be careful to infuse exactly enough and no more moon-glow into the student's engineering work. As an example, and warning, of the need for a discreet love for one's profession, permit me to cite a case brought to light by an official of a large all-metal automobile body manufacturing company. The incident centers about a devoted young couple (one of the plant's engineers and his wife) watching over their baby in an all-metal crib. The father sits on one side and the mother on the other. Through the mother's dreams looms the future of her wonderful offspring. She is certain that when he goes to kindergarten he will be the brightest kiddie in the class. Then when he goes on to prep school, he will be the most popular and best-looking boy, will be captain of the football team, and he will lead his class in scholarship. At college, she visualizes his becoming an All-American tackle and of course a Phi Beta Kappa. Upon graduation, he will proceed by easy stages to the governorship of the state. As a United States Senator he will make a name for himself and his family, and finally at middle age, as President of these United States, he will lead the country to better things. At that moment she raises her head and murmurs to her husband, "A penny for your thoughts, my dear!" He starts, and with a look of deep concern on his face says, "I was just tryin' to figger out how in hell they can make that crib for $2.98!"

Fortunately, I doubt whether even our most intensive inspirational efforts will very often lead to similarly fatal results; therefore let us not hesitate to develop professional zeal in the student during his formative college days.

It goes almost without saying that observational powers and experience are useful, if not indispensable, as tools for unveiling all too obvious as well as deeply hidden problems. I believe that powers of observation can be developed, and that experience can be transplanted to rather than suffered by the student. The engineering instructor should not pass on only his own experiences to the student but should direct the student to sources where, through reading both during and after college, he can learn to observe by standing figuratively at the side of such men as Faraday, Brewster, Newton and others; where through reading he can obtain "experience" in a measure far beyond that which may come to him of its own accord.

Having once recognized a problem, the engineer should then be able to analyze it in terms of the fundamental laws or principles involved. More than a factual knowledge of principles is necessary; the principles must be thoroughly *understood* if they are to be recognized and used. The importance of a true knowledge of fundamentals cannot be over-emphasized and I contend that we

should resort to *anything* which will impress fundamental laws and their full significance upon the student—regardless of whether or not academic dignity and methods are violated by so doing. Simple and above all associative illustrations should be used freely. They are scarce of course, but their value to the student and to us as a teaching device is so great that we should constantly be on the alert for them.

A knowledge of fundamentals is of little avail if we are unable to recognize them. Allegedly, engineering students are trained to distinguish the components of which a problem is constituted. When I look back at my seven or eight years of student life at different universities, I am convinced that many instructors were not themselves aware of the difference between applying formulae and making a true analysis. They were not necessarily poor teachers, or impractical engineers; they simply failed to pass on to the student the really good technic that they themselves used when sparring with new problems. We ourselves are usually able to pick or modify a formula to serve in the solution of a problem because of our experience or ability to make rapid appraisals. Let us remember that the student is a tyro to whom a slow-motion talkie of our semi-automatic analytical reasoning should be of more value than any other phase of his class work. I believe the seminar to be the Utopian setting for the performance but there is no reason why it cannot be given before much larger and more formal gatherings.

After a calm analysis of the problem has been made, and the fundamental laws, together with the simplifying assumptions, have been tabulated, the task of expressing the analysis in the shorthand of mathematics presents itself. I wonder if there is any way we can permanently impress the student with the full significance of symbols? The use of letters and symbols for representing physical quantities is supposedly understood by the student and yet, when pictures such as force polygons are used, he is inclined to think of the vectors representing the forces as *being the forces.* Such misconceptions lead to a terrific handicap when attempts at true analyses of physical states are made in advanced work. What the cure might be I do not know, but I feel that some good would come of re-emphasizing the true meaning and rôle of symbols at the beginning, and at frequent intervals, of all engineering and mathematical courses. In addition I am inclined to favor the use of varied, but in themselves consistent, sets of symbols for describing identical phenomena. This would aid materially in breaking down the incorrect interpretation of symbols and require the student to understand problems thoroughly in the light of fundamental laws rather than as an incantation of Greek symbols. I do not wish the preceding statements to be construed

as an indication of my feelings on the desirability of uniform notation. I think uniform notation is good for a profession and its followers, but I also feel that we have been overlooking the educational advantages of diversified notations, the advantages that the student might derive from being compelled, through reference reading, to follow generally similar problems as analyzed in texts employing different notations. Such required reading would soon develop sound fundamental thinking and do much to reduce the status of the formula in the mind of the student.

Discrete combinations of symbols constitute equations. These equations are really nothing more than pictures of states, conditions or laws. The student, in his mathematics and engineering courses, learns to set up equations, but for some reason he soon develops a deep aversion to the process. Somewhere he gets the idea that setting up mathematical expressions for the fundamental relationships in a problem is part of a "derivation." To him the *result* of the derivation becomes the important phase, and such things as initial assumptions are of no consequence. To him the technic of establishing equations (recognition of fundamental relationships, introduction of simplifying assumptions, etc.) is a task belonging to the instructor and is to be borne with an air of martyrdom; or ignored completely if the instructor is known to be one who never requires a "derivation" in his examinations.

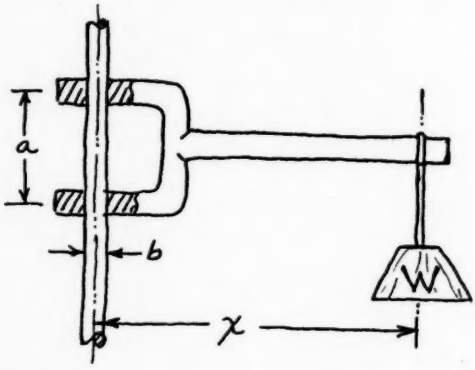
I feel that many of our courses, both in mathematics and engineering, are making the mistake of trying to mechanize the subject matter; or trying to arrange the subject matter into type problems, each of which has its own specific formula solution. Throughout my own teaching work I have had an almost irresistible urge to shatter each formula as it appears by citing so-called type problems which will *not* yield to solution through them. This of course would not do if the student's morale is to be kept up. However, I find that a certain amount of such disillusionment is good for the soul and definitely encourages faith in fundamentals. Why cannot our engineering courses (and mathematics courses as well) place less emphasis on the type solution and more on setting up problems both verbally and mathematically—on requiring complete exposition of problems with the laws and assumptions involved, both in good English and in good mathematics? We have talked about this time and time again and agreed to the merit of such procedure. Many institutions are employing it successfully in the teaching of integral calculus. The problem is stated briefly and clearly (very often copied, which is fair exercise) and the integral is set up from a *neat* sketch or mental picture of the problem. Manipulative stages are omitted until the formulative technic has been mastered to the extent that errors are a rarity. The evi-

dence seems to be such as to warrant an extension of this method to other fields of student instruction. The time we spend on formulae is appalling. I have often wondered whether a little reform along this line would not alleviate some of our problems of limited curricular time and also give the student a really intelligent understanding of the subjects he studies.

Mathematics, as it is usually taught, requires first of all an equation to work upon. Engineering students are in pathetic straits when confronted with the necessity of setting up a problem from observed data. The mechanism of setting up equations which was learned in Mechanics, for example, will not work here and they realize suddenly that something more is needed: a logical method for expressing data in mathematical form. I submit that the student should be given more work in preferred methods of plotting data (the use of log papers, functional scales, etc.), curve fitting and the immediately related subject of probability. Our mechanical engineering department has made definite efforts to train the student along these lines in conjunction with his laboratory exercises—a most logical place for this work but by no means the only place where it might advantageously be stressed. One of the greatest drawbacks to teaching the art of curve-fitting obviously centers on the fact that no elementary and really practical treatment of the subject is available in book or pamphlet form.

The question of units can never be dismissed from engineering analyses. We learned long ago that "apples plus apples equals apples"; yet how often we forget the fundamental implication of this statement when we concern ourselves with the combinations of torques, accelerations, etc.! In most of our engineering teaching we hurriedly indicate the need for dimensional homogeneity in equations and pass on without discussing the possibilities of analysis through dimensions, dimensionless criteria and the laws of similitude. I anticipate an objection to the effect that "dimensional analysis" is too formidable a subject to offer to the student. Perhaps the subject does have an awe-inspiring title; nevertheless the principles involved are quite easily understood—provided that we avoid some of the so-called standard literature on the subject! Instead of feeding the student on dimensional analysis in its philosophical or super-elegant phases, why not give a common sense engineering version of the subject and use actual engineering examples for illustrations? I do not agree with qualifications intimating that dimensional analysis adapts itself only to certain favored fields. It is not unusual to employ this art (if I may call it that in view of the mystic reverence accorded it) for advanced work in hydrodynamic and thermodynamic studies—yet we pass by very important everyday applications, in these and

other fields, which would do the undergraduate a world of good. I cannot recall a single instance in my college training (and I feel that I went to at least average institutions of higher learning) where similitude was even mentioned in connection with laboratory tests. I actually thought geometrically similar things were similar in their behavior and physical characteristics! And neither do I recall ever having been told very much about dimensions other than to use consistent units. The complaint that only a certain few problems are adaptable to dimensional analysis is untenable. I would like to cite an unexpected yet simple application in Mechanics. . I think it will illustrate a fundamental reasoning process which is valuable in that it aids the student in sensing a problem and the variables involved.



A forked lever is mounted on a vertical shaft as shown. The problem requires the student to determine the weight W and the coeffiecint of friction μ for impending motion in terms of a, b, and x. The student usually succeeds in setting up the fundamental equilibrium equations and in manipulating these three equations to obtain the correct relationship:

$$Wx = \frac{Wa}{2\mu},$$

and then, in pace with time-honored tradition, he "cancels out" the factor W. Suddenly he comes to the realization that despite the most diligent manipulation of equations he cannot get an expression for W although he can easily express μ (correctly) as:

$$\mu = \frac{a}{2x}.$$

Some students recognize that W can have any value and therefore that impending motion is not dependent upon the magnitude of the suspended weight—an intelligent interpretation of the "cancelling" process. But even then they are often disturbed by their inability to express W in terms of a, b and x! All too seldom it occurs to a student that W, being a weight, could not possibly be expressed in terms of linear dimensions only. A simple dimensional analysis, if I may call it that, would have quickly apprised the student of the difficulties ahead of him. He could have said to himself, "W is to be expressed in terms of the *lengths* a, b and x—why, that's impossible!" and thereby have avoided a great deal of unnecessary work and worry.

More complex problems yielding to quite as simple an analysis could be devised. They would, I believe, serve well to implant more firmly the basic implications of units and homogeneity, and tend to encourage thinking in terms of fundamental functional relationships. Such thinking would also help a great deal in the intelligent appraisal and segregation of grouped data.

I propose to say very little about the manipulation of mathematical forms. The training the student receives in this connection, although somewhat lacking in diversity, is excellent and deserving of commendation. However, being in a mildly critical state of mind, I should like to take issue with the usually recommended process of mechanical and non-interpretative manipulation. I feel that somewhere the student should be encouraged to visualize the physical significance of what he is doing. Of course such physical interpretation is not always possible, but when it is, I feel that one learns a great deal more about the fundamental laws involved in the initial analysis—perhaps even becomes aware of long-harbored misconceptions regarding them.

Most of us will agree that formally at least the so-called answer is the culmination of a given mathematical manipulation. In engineering, this formal answer has acquired a rather distasteful name that smacks of the medieval: *Formula.* So much has been said about formula engineering, that charming science of trying to fit standardized forms of equations to *almost* standard types of problems, that one wonders why more is not done about it. Why can we not break away from the time-honored procedure of substituting numbers into a formula? The most common reason I believe to be the difficulty of selling students the idea that there may be more to a problem than a numerical answer and that the thinking process is really a remarkable and often easy way to solve problems of all sorts, whether they result from class work or from everyday living. Would an engineering course necessarily degenerate either professionally or mathematically if we spent less

time "solving" problems and more on simply setting up the problems, establishing the assumptions and then sitting back to contemplate the limitations and significance of the known solution? I think much good would result. Why, perhaps even a good strain of handbook engineers might be produced through such a procedure! It is of course true that this suggested routine is followed in some classes, but very few indeed give the matter its deserved emphasis.

An instructor should not stop at interpretations in the light of the particular subjects being studied; he should try to dig back into the students' past training, recalling related problems from related fields once studied, and judiciously open the future by indicating the applicability of a particular solution to analogous problems in other branches of engineering. Flow problems offer the greatest opportunities in this line for similar equation forms are consistently encountered in the study of the flow of fluids, heat and electricity. Someone will object to this suggestion on the grounds the Laplacian and Cauchy-Riemann relationships are beyond what we can reasonably expect the student to comprehend. I do not accede to this, although I do admit its truth when considered from the point of view that we are to reserve these vital relationships as pearls to be cast in graduate courses. The Laplacian description of orthogonal networks can be approached mechanically and understood by the average junior student. True, some rigor may be omitted and certain elegance will be sacrificed, but this is more than offset by the fact that we have given the student a key to the unity of science and perhaps an incentive to broaden his interests beyond the confines of his special field.

A great many accidental analogies also exist. Their discovery depends upon wide experience in more than one branch of engineering as well as better than average observational powers. It is up to the instructor to point out these analogies. They occur in many fields. For example we can describe torsion by a soap film or sand pile analogy, while the similarity of Ohm's law and D'Arcy's law for the flow of water through sand yields an electrical method for solving problems of seepage under dams. Quite often too, we neglect to recognize that certain mathematical oddities are really of important physical significance. As an illustration of the last point I might ask just how often instructors in Analytic Geometry point out that the Cassini ovals are the loci of points of equal force as defined by Coulomb's law for the mutual attraction of two similarly electrically charged particles at a fixed distance from each other? Then too, how often is it that an instructor bothers to elevate such earthly things as the equation for the volume of a uniformly thick plate, $V =$ area x thickness, by

relating that it was used as the basis of Irving Langmuir's famous oil-film experiments in which he so beautifully and simply conquered the formidable problem of determining molecular thicknesses? Such anecdotes would serve many purposes. They would indicate the importance of common sense, mental alertness, and definitely encourage the student who has become frightened by the real or imaginary difficulties in contemplated fields of study. In addition they would help supply the color which is so sorely needed by many of our engineering and mathematics courses.

I do not wish to convey the idea that the phase of numerical substitutions should be completely subjugated. Sufficient work of this kind should be included so as to develop reasonable proficiency. But we must also remember that practice alone does not necessarily mean the eventual development of perfection. It is of far more importance to build up the student's confidence, not only in his "arithmetic" but in his resourcefulness as well. He should be exercised in more than orthodox or routine numerical substitutions. The student deserves a greater variety of work, particularly that involving methods of approximation and the technic of mechanical solutions. It is disconcerting to see how seldom students will employ graphical methods. I think this is due to their weak background and resulting uncertainty in this method of solving problems. As I recall, I was in college seven years before I encountered the use of weighing balances for integrating areas under curves. The curves were simply drawn on cardboard of a known weight per unit area, cut out and weighed—what could be more simple? I have seen hours spent on problems which might have been solved quickly by equally simple expedients. Instead of insisting on pseudo-elegance in finding centers of gravity of complex cross-sections, for example, why not encourage the student to obtain his results experimentally by the use of paper or sheet metal models?

Experimental methods are not necessarily always the quickest. Some amount of discretion and shrewdness must enter into the selection of methods for approaching any problem. Purely mathematical analyses very often prove to be rapid as well as accurate. An illustration comes to my mind as I recall the case of an alleged engineer in a large manufacturing company who spent about one week, and an appreciable amount of money, in determining experimentally the variations of angular velocity in a shaft driven through a universal joint. A very simple kinematic analysis would have given a precise general solution of the problem in a half hour. It seems that most people display an inevitable faculty always of picking the longest and most difficult method for solving their problems. This cannot be attributed wholly to a lack of judg-

ment. A great deal of the trouble lies in the fact that these persons are unaware of the existence of other methods which would be more suitable. A gifted few may be able to devise their own methods of rapid analysis, but on the whole I feel that most of our students would benefit greatly from at least an introduction to the many amazingly ingenious methods of analysis that have been devised for circumventing commonly encountered analytical difficulties.

In the light of their somewhat infrequent use, it is doubtful whether we are justified in consuming more time than that required for introducing the student to these methods. By the same token manipulative proficiency is of relatively little importance and too exorbitantly priced.

My hope is that I have succeeded in presenting satisfactorily my "definition" of engineering mathematics, and in directing attention to seemingly pertinent pedagogical off-shoots which to my mind are inseparably associated with such a formulation. Graduate courses may or may not present totally different problems than those encountered in the undergraduate courses at which the preceding comments were directed. However, I feel these comments have been expressed with sufficient generality to make them applicable to conditions in the seventh as well as the first year of normal collegiate study.

Most of the suggested practices, or reforms if you wish, can be incorporated into all courses without any appreciable physical rearrangement, and without any pedagogical fanfare. The greatest demand as usual will be of the instructor, but the benefits of his labor will be widespread and he himself should profit greatly. Is it not conceivable that a 2 or 3 unit course in Engineering Appreciation might be placed in present Junior or Senior schedules? In such a course general mathematics and engineering would be discussed qualitatively and informally, the principal stress being laid upon the origin and formulation of problems, and the critical evaluation of the results or solutions—no manipulative work would be required. Selected articles from current periodicals and transactions could thus be used for simultaneously instructing and keeping apace of modern engineering inter-relationships.

Who would teach such a course? The presentation and interrelation of the basic as well as the current material in many fields of engineering require of the instructor exceptionally wide experience, deep interest and unusual ability. Perhaps such a task would demand the attention of two or more capable instructors.

In as much as many of our courses in engineering are given in other departments, the problems of coöperation, or the lack of it, are always before us. Tolerance must be the by-word, particu-

larly when an engineer naïvely dares to *tell* a scientist what he should teach engineering majors! Greater understanding and "for-the-cause" feeling among instructors might result from mutual inquisitiveness about the contents of associated courses. Such well intended curiosity and the resultant discussion between the principals would afford an unobtrusive way of eliminating duplication of work and also bring to light unsuspected omissions of important theory and practice.

In closing, I submit that the extent to which we satisfy the indicated mathematical requirements of the engineering student is a direct measure of how effective we, both mathematicians and engineers, are in the teaching of engineering mathematics.

Perhaps the chairman will now ask Dr. Goldsworthy to release the second unicorn for us?

COLLEGE NOTES

Colorado School of Mines.—The remarks of Col. Willard T. Chevalier climaxed the annual Engineers' Day program. More than 300 practicing engineers and friends of the profession mingled with the Mines students at this annual function, sponsored by the Colorado Engineering Council, Professor Clark B. Carpenter, Chairman, Dean Jesse R. Morgan and Professor J. Burns Read. President M. F. Coolbaugh presided. R. C. Gowdy, chief engineer of the Colorado and Southern Railroad, introduced Colonel Chevalier.

As vice-president of the McGraw-Hill Company, Mr. Chevalier is unquestionably in a position to keep his fingers on the pulse of engineering progress. There was no note of pessimism in his remarks as he reported "An Engineer's Survey of the Changing Scene."

Massachusetts Institute of Technology.—At its Third annual meeting, held January 30, at Columbia University, the Institute of the Aeronautical Sciences bestowed the Sylvanus Albert Reed Award jointly upon Professors C. G. Rossby and H. C. Willett, both members of the Technology faculty. The Reed Award, the highest honor that is given for scientific work in aeronautics, was established by Dr. S. A. Reed of New York, who pioneered in the development of the duraluminum metal aircraft propellor. Professor Rossby and Dr. Willett together have applied advanced meteorological methods to the forecasting of American weather by developing the polar front theory which Rossby originated.

Two important research projects will be developed by a gift of $10,000 from Sir Douglas Alexander, president of the Singer Manufacturing Company.

Five thousand dollars of the gift will be used for construction of a large calculating machine for the mechanical solution of simultaneous algebraic equations. A laboratory model of this machine, which was designed by Professor John B. Wilbur of the department of Civil Engineering, was completed recently. Its successful operation demonstrated the possibilities of a machine of sufficient size to solve many important engineering and scientific problems with the degree of accuracy necessary for engineering design.

The chief use of this machine will probably be found in the analysis of stresses in various types of engineering structures, such as buildings, bridges and airplanes. Other applications can be made in such diverse fields as surveying and psychology.

The balance of the fund has been allotted to the initial equipment and operation of a new laboratory for research and testing in the field of dynamic strength of materials. This work will be done under the supervision of Professor A. V. de Forest in the Department of Mechanical Engineering, an authority of wide experience and reputation in this field, who joined the staff of the Institute last October. This research will be concerned largely with the effects of surface conditions, such as scratches, corrosion and crystal formations, as determined by the working and heat treatments of the sample, on its strength and durability under continuous use. It is found that such conditions on the surface of parts of engineering structures, which appear at first sight to be of negligible importance, are often the predominating factors in determining the safety and durability of the part in question.

A new graduate course in professional engineering practice, designed to give students an insight into the practical problems encountered in an engineer's office, will be given during the second term at the Massachusetts Institute of Technology.

The new course, which will be directed by Professor Charles M. Spofford, of the department of civil and sanitary engineering, will consider the ethical and professional codes of the engineer in relation to his clients, contractors, fellow engineers and the public. It will also include a study of engineering costs, fees and salaries, the standard specification of materials, and the preparation of contract documents and technical reports. Problems of engineering office methods, estimates of construction costs and revenue for various types of engineering projects, and other aspects of the profession will be discussed at length.

The students will be required to interpret various contract and specification clauses, to pass upon ethical, business and engineering questions arising in practice, and to prepare for class discussion contracts for engineering services and specifications in whole or part for simple projects. The course will be illustrated with numerous examples from actual engineering practice.

Newark College of Engineering.—Mr. Roy V. Wright is in charge of a course in the Engineer's Duty as a Citizen. The course includes three two-hour periods and the following topics are discussed:

I. What Responsibility has the engineer as a citizen?
II. How can the engineer, an individual, discharge his civic responsibilities?
III. How can the engineers, as group, discharge their civic responsibilities—local, state, and national?

Northeastern University.—Dean Carl S. Ell addressed the Schoolmasters' Club of Massachusetts on the "Social Significance of the Coöperative Plan." The present school year signalizes a quarter of a century of steady, wholesome, substantial development of coöperative education at Northeastern University under his inspiration and guidance.

The first class of coöperative engineering students which entered in 1909 comprised only eight men: four in each division. They coöperated with the Boston and Maine Railroad, the Boston and Albany Railroad, the Boston Elevated Railway, and the Boston Consolidated Gas Company, alternating between class work and engineering practice at one week intervals. "Co-ops" were paid ten cents an hour during the first year, twelve cents an hour during the second year, fourteen cents an hour during the third year, and sixteen cents an hour during the fourth year which enabled them to earn from five to seven dollars a week.

Instruction was given by four part time teachers and classes were held both day and evening. In addition to Dr. Speare and Dean Ell, Galen David Light, now Treasurer of the University, and Prof. William Lincoln Smith, now head of the Electrical Engineering Department, were also on the staff when the coöperative courses were first introduced.

From its small and humble beginning, the coöperative plan at Northeastern University has become one of the largest in the country, enrolling about 1,800 students. All curricula are five years in length leading to the Bachelor of Science degree in engineering and business administration. Plans are formulated for housing the University in a new plant on land which is already available adjacent to the present buildings. It is expected that the engineering building, first of the new group to be erected, will be started in the near future.

Purdue University.—Professor W. A. Knapp has been named Assistant Dean of the School of Engineering. For some years he has been in charge of the Engineering Extension Department.

Purdue University has adopted a common curriculum for all freshman engineers, which will make the first engineering year an orientation period and enable a student by study and experience to decide intelligently upon the particular course of engineering which he desires to study. The new common curriculum will go into effect with the opening of the academic year next fall.

The new curriculum will lighten the load for freshman engineers by reducing the number of required credit hours by about three in order to give the new student a better chance to adjust himself to new conditions. There will be an increased amount of

time given to chemistry, and every student will be required to take surveying and some shop work in order that he may learn early in his engineering course to use tools and instruments.

It also provides for shifting more of the elective work to the upper years in engineering. Through revision of the curriculum, engineering students will have between 27 and 34 hours of free electives on non-technical subjects in their final years of training.

EMPLOYMENT SERVICE

The Secretary circularized all engineering colleges asking them to list any vacancies in their staffs. We are receiving these, and now ask any member who wishes to change his position to send to this office complete information concerning his education, experience, references, etc. This service is free to members. Information should be sent to the Office of the Secretary, S. P. E. E., University of Pittsburgh, Pittsburgh, Pa.

BOOK REVIEW

Resistance of Materials. FRED B. SEELEY. Second Edition. 436 pages. John Wiley & Sons. $3.75.

This book fulfills the aim of the author, which he states as follows: "It has been the aim in preparing this second edition to give special emphasis to the engineering significance of the subject and not merely emphasis to the mathematical method of analysis."

The first chapter introduces the student to the subject by the use of elementary problems before going into the tiresome, but necessary, general discussions of stress and strain.

The chapter on elementary combined stress in the first edition has been combined in later sections dealing with this subject.

The book has been arranged so that either integration or momentera method of finding deflections can be used.

The chapters dealing with fatigue of metals, stress concentration, and impact loading have been enlarged in keeping with the importance they have in design today, and have been brought up to date.

The second part of the book covers special topics such as Unsymmetrical Bending, Flat Plates, Torsion of Non-Circular Bars, and Composite Beams.

This book is more than "just another text" and is deserving of review by teachers of strength of materials.

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